Immersion in Hot Spring Improves Cardiovascular Functions in Patients with Chronic Heart Failure

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I INTRODUCTION

Congestive heart failure (CHF) is a common syndrome mostly affecting subjects over the age of 65 years.1 Heart failure has extremely poor prognosis in spite of recently developed cardiovascular pharmacological therapeutics. It is well known that therapeutic exercise has beneficial effects and has traditionally been used as an alternative non-pharmacological treatment for patients with CHF. Recently, Tei et al. reported that bathing in a hot bath has potential benefits for patients with CHF.2 They reported that a hot sauna is also effective for patients with CHF.

Some reports have shown that bathing in a hot spring reduces systemic vascular resistance in CHF patients.3,4 However, it is still under debate whether hyperthermia in a hot spring improves the status of CHF. We hypothesized that hyperthermia using a hot spring improves the peripheral endothelial function and clinical symptoms. The purpose of this study was to elucidate the beneficial effects of hyperthermia treatment using a hot spring in patients with chronic heart failure.

II MATERIALS AND METHODS

1. Patient population

The study population was comprised of 26 patients (10 patients with dilated cardiomyopathy, 16 patients with ischemic cardiomyopathy) with chronic systolic heart failure classified as New York Heart Association (NYHA) functional status II or III, and significant left ventricular dysfunction. The Institutional Review Committee in Human Research of the Faculty of Medicine, Kyushu University, approved the study protocol. We obtained written informed consent from each subject before the study.

After stabilization of their clinical status, all patients underwent a detailed evaluation of physiological parameters including heart rate (HR), blood pressure (BP), left ventricular ejection fraction (LVEF) by echocardiography, brachial-ankle pulse wave velocity (baPWV) by automatic device, and cardiothoracic ratio (CTR) by chest X-ray, as well as biochemical parameters including asymmetric dimethylarginine (ADMA) and brain natriuretic peptide (BNP) before and after treatment. Patients with significant valvular failure, a LVEF > 60%, only right ventricular dysfunction, diastolic dysfunction, and patients whom medical doctors restricted from bathing due to severe physical status were excluded from the study.

2. Balneotherapy

The patients were divided into two groups. In the balneotherapy group, patients immersed their bodies to the sternum or below (half-body bathing) in a hot spring at 40℃ for 10 min. The bathroom temperature was maintained at around 28℃ to prevent heat loss from their bodies. After bathing, patients rested for one hour to keep their bodies warm. Balneotherapy was performed daily (five days a week) for two weeks. The patients maintained their other daily habits. Patients in the control group took a shower daily for two weeks.

3. Statistical analysis

All values are expressed as means± standard deviation. Differences between means were compared by paired or unpaired Student t test, as appropriate. P < 0.05 was considered significant.
III RESULTS

1. Clinical characteristics
Table 1 lists the baseline characteristics of the study subjects. There were no significant differences between the two groups.

2. Effect of hot spring on deteriorated cardiovascular function
HR and CTR did not change before and after treatment in either group. However, the NYHA classification and mean BP decreased significantly after treatment in the balneotherapy group (Table 2). Moreover, LVEF drastically improved after hot spring immersion for two weeks. On the other hand, there were significant differences in hemodynamic variables of the control group before and after the two-week period of daily showering. These results suggested that cardiac function and thereafter cardiac remodeling improved over those two weeks.

3. Effect of the hot spring on imbalanced biophysical and chemical parameters
Figure 1 shows the level of plasma ADMA and BNP in each group before and after intervention. In the balneotherapy group, PWV, ADMA and BNP decreased significantly after treatment (Fig. 1). However, these parameters did not change statistically after intervention in the control group (PWV: 16.5±0.7 versus 17.0±0.7 m/sec, ADMA: 0.59±0.03 versus 0.61±0.03 pg/ml, BNP: 302.1±66.4 versus 430.4±192.1ng/ml).

IV DISCUSSION
The novel findings of the present study are that immersion in a hot spring improved (1) LVEF and CTR, and (2) PWV and ADMA, suggesting peripheral vascular circulation.

Balneotherapy
Conventionally, bathing has been recognized as harmful and even exhausting for severe CHF patients because thermal stress increases the cardiac workload and sympathetic activity, thus leading to decompensation of cardiac failure. However, the recent tendency has been to recognize that careful bathing and/or dry sauna is safer than it was thought to be.3, 5-7) Half-body bathing has similar effects as whole-body bathing, and the deep-body temperature increases approximately 1 degree after half-body bathing.8) The present study suggests that bathing at 40°C for ten minutes can be safely performed even in CHF patients.

Cardiac function
In a warm water bath, patients with CHF demonstrated that oxygen consumption increased mildly, pulmonary arterial blood temperature increased by 1.2°C, and heart rate increased by 20 to 25 beats per minute at the end of bathing. Systolic blood pressure showed no significant change, but cardiac and stroke indexes increased and systemic vascular resistances decreased significantly during and after bathing. Mean pulmonary artery, mean pulmonary capillary wedge, and mean right atrial pressures increased significantly during bathing but were significantly lower than the control levels after bathing. Cardiac dimensions decreased and the left ventricular ejection fraction increased significantly after bathing.3, 4) Moreover, repeated low-temperature dry sauna treatment improved vascular endothelial and cardiac function in patients with chronic heart failure.5, 9) Therefore, heating bodies
**Table 1 Patient Profile**

<table>
<thead>
<tr>
<th></th>
<th>Treatment group (n=13)</th>
<th>Control group (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y.o.)</td>
<td>75.0±3.4</td>
<td>72.1±4.5</td>
</tr>
<tr>
<td>Male / Female</td>
<td>7 / 6</td>
<td>6 / 7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>154.1±2.9</td>
<td>154.6±2.1</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>51.4±2.6</td>
<td>52.0±2.6</td>
</tr>
<tr>
<td>ICM/ DCM</td>
<td>8 / 5</td>
<td>8 / 5</td>
</tr>
</tbody>
</table>

*ICM = Ischemic cardiomyopathy, DCM = Dilated cardiomyopathy, Mean ± SE*

**Fig.1** baPWV (a), BNP (b) and ADMA (c) improve after bathing in a hot spring.

**Table 2 Effect of Balneotherapy**

<table>
<thead>
<tr>
<th></th>
<th>Balneotherapy group (n=13)</th>
<th>Control group (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>NYHA (I/II/III/IV)</td>
<td>0/6/7/0 (2.53±0.14)</td>
<td>1/12/0/0 (1.92±0.07)*</td>
</tr>
<tr>
<td>(mean)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>73.4±3.6</td>
<td>72.4±4.1</td>
</tr>
<tr>
<td>mBP (mmHg)</td>
<td>85.2±2.7</td>
<td>81.2±2.5</td>
</tr>
<tr>
<td>CTR (%)</td>
<td>56.1±2.5</td>
<td>54.1±1.9</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>49.0±4.4</td>
<td>58.0±3.2</td>
</tr>
</tbody>
</table>

*NYHA = New York Heart Association
mBP = Mean blood pressure
CTR = Cardio Thoracic ratio
LVEF = Left ventricular ejection fraction

Mean ± SE

* P < 0.05 vs before treatment
passively with external stimuli might have therapeutic benefits for patients with CHF.

Peripheral vascular function

There is now considerable evidence that patients with CHF have abnormal endothelial function in both large conduit and small resistance vessels.\(^{10-12}\) baPWV reflects the flexibility of conductance vessels and ADMA is an endogenous inhibitor of nitric oxide (NO) synthesis and elicits cardiovascular effects when administered to humans.\(^{13-15}\) Elevated plasma ADMA concentrations have been described in patients with HF.\(^{16,17}\)

There is also a significant relationship between baPWV and BNP.\(^{18}\) Vasodilatation induced by hyperthermia may increase the vascular shear stress and production of endothelial nitric oxide. Therefore, repetitive hyperthermia may improve endothelial and cardiac dysfunction, which would decrease baPWV and ADMA.

Recently, evidence that vascular endothelial dysfunction predicts future cardiac events has been accumulating.\(^{19,20}\) Moreover, the present study suggests the possibility that improvement of endothelial dysfunction and cardiac dysfunction by balneotherapy may reduce cardiovascular events.

Limitation of the study

Several limitations of this study should be mentioned. First, only a small number of patients were studied. Second, there is no direct evidence that endothelial dysfunction in patients with CHF improved after bathing in the hot spring. Third, we did not measure the cardiovascular hemodynamic variables during bathing. We need to take into consideration that patients with CHF have lower cardiopulmonary function and water pressure during bathing increases venous return, cardiac output and cardiac internal pressure, thus exhausting a compensated failing heart. However, researchers have suggested that bathing at 40°C for 10 min is quite safe and favorable for bathing.\(^{3,5-7}\) Indeed, the present study was conducted under the observation of medical doctors, and no patient enrolled felt subjective worsening of heart failure symptoms including fatigue, shortness of breath or fainting, or dropped out the study. Fourth, it is not certain whether the beneficial effects of balneotherapy for patients with CHF are produced only by the hot spring. Previously, investigators reported that the thermal effect of a sauna (i.e., steam bath) was better than hot water\(^{3}\) while the differences between hot spring and hot water were quite small\(^{21}\). However, from the possible mechanisms of hyperthermia, warming of the body either way might have similar beneficial effects for patients with CHF. Indeed, repeated dry sauna therapy also is therapeutically effective for patients with CHF.\(^{5,9}\)

The opportunities to bathe are sometimes limited in patients with heart failure because of impaired activities of daily living and cardiopulmonary function, and/or disabilities of the extremities. Therefore, bathing has hygienic as well as therapeutic benefits for patients.

In this study, a small number of patients were studied. Consequently, a large-scale randomized case-controlled study is recommended to establish this non-pharmacological alternative therapy for aged patients with CHF.

V CONCLUSION

The present study demonstrates that repeated immersion in a hot spring improves cardiac dysfunc-
tion and impaired peripheral vascular endothelial function, thus leading to improvement of clinical activity and symptoms in patients with CHF. Balneotherapy may be an excellent alternative, non-pharmacological therapy for aged patients with heart failure, especially those who cannot undergo appropriate exercise rehabilitation.

VI ACKNOWLEDGMENTS
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Reference
17) Ohnishi M, Wada A, Tsutamoto T, et al. Endothelin stimulates an endogenous nitric oxide syn-
Objective: The purpose of this study was to examine the beneficial effects of balneotherapy in patients with chronic heart failure (CHF).

Background: Some reports have shown that balneotherapy reduces systemic blood pressure in healthy volunteers. However, it is not clear whether balneotherapy improves the status of CHF. We hypothesized that hyperthermia using hot water would improve cardiac and peripheral endothelial function and clinical symptoms.

Methods: Twenty-six patients with chronic systolic heart failure classified as New York Heart Association (NYHA) functional status II or III were divided into two groups. In the balneotherapy group, patients were immersed in a hot spring at 40°C for 10 min daily for two weeks; in the control group, patients took a daily shower. We measured plasma brain natriuretic peptide (BNP) and asymmetric dimethylarginine (ADMA). The left ventricular ejection fraction (LVEF) and cardiothoracic ratio (CTR) were evaluated by echocardiography and chest radiography, respectively. Brachial-ankle pulse-wave velocity (baPWV) was measured non-invasively using an automatic device.

Results: Clinical symptoms were improved after two weeks of hot spring therapy. Although heart rate and CTR did not change, clinical symptom and LVEF improved and mean blood pressure, BNP, ADMA and PWV significantly decreased.

Conclusions: Repeated immersion in a hot spring improves peripheral vascular endothelial function, thus leading to improvement of clinical activity and symptoms in patients with CHF.